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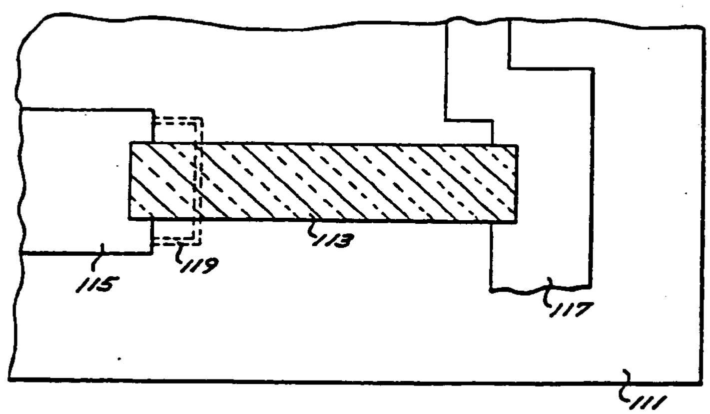
(54) Title: INDUCED METALLIZATION PROCESS BY WAY OF DISSOCIATING ALUMINUM NITRIDE CERAMIC



(57) Abstract

A process for forming electrically conductive circuitry on a metallic nonconductive substrate or insulating layer which includes the steps of providing a nonconductive ceramic substrate having a metallic component and which can dissociate into its constituent components to provide dissociated metal bonded to the ceramic substrate upon application of laser energy. Laser energy is then applied to predetermined areas of the surface of the nonconductive ceramic substrate to provide dissociated metallic conductors in the predetermined areas. The disclosed process further includes the formation of metallized through holes by application of laser energy to the nonconductive ceramic substrate to form a through hole, whereby dissociated metal is formed on the inside of the through hole. The disclosed process also includes the capability to down trim a thick film or thin film resistor which is conductively coupled between two areas of metallization. Laser energy is applied to a portion of the thick film or thin film resistor and to a portion of the metallic nonconductive ceramic substrate in a predetermined pattern to provide a continuous dissociated metallic conductor which passes through the thick

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INDUCED METALLIZATION PROCESS BY WAY OF DISSOCIATING ALUMINUM NITRIDE CERAMIC

BACKGROUND OF THE INVENTION

The disclosed invention relates to the formation of electrically conductive circuitry on a nonconductive substrate, and is more particularly directed to a technique for selectively dissociating the localized portions of an aluminum nitride ceramic substrate or insulating layer to form electrically conductive circuitry thereon.

Hybrid circuit structures, also known as hybrid microcircuits, implement the interconnection and packaging of discrete circuit devices, and may include one or more nonconductive ceramic substrates or layers for supporting circuit elements, which may be mounted on both sides of the microcircuit. Conductor runs for interconnecting circuit elements are formed on the surfaces of the substrate or subsequent layers, and metallized vias may be provided for interconnecting circuitry on the two sides of a ceramic substrate or between layers.

Conductor runs, for example, can be formed by thick film screen printing or thin film metallization techniques, and via metallization can be provided by thick film screen printing techniques. However, as is well known, such techniques take time and require several steps. For example, thick film screen printing requires the preparation and use of silk screens and the application of conductive paste, while thin film metallization requires chemical vapor deposition, masking and etching.

A further consideration with conductor runs formed with known techniques is the inability to trim resistors to decrease resistance values. Generally, trimming of resistors with present techniques can only increase resistance values.

SUMMARY OF THE INVENTION

It would therefore be an advantage to provide a simplified process for forming electrically conductive circuitry on a nonconductive ceramic substrate or insulating layer.

Another advantage would be to provide a process for forming electrically conductive circuitry on a nonconductive ceramic substrate or insulating layer which avoids thick film and thin film metallization processes.

It would also be an advantage to provide a process for forming electrically conductive circuitry on a nonconductive ceramic substrate or insulating layer which avoids the application of conductive material thereto.

A further advantage would be to provide a process for forming electrically conductive circuitry on a nonconductive ceramic substrate or insulating layer which allows for trimming resistors to decrease resistance values.

A still further advantage would be to provide a process for metallizing vias through insulating layers or metallic nonconductive substrates.

The foregoing and other advantages and features are provided in a process for forming electrically conductive circuitry on a metallic nonconductive substrate or insulating layer which includes the step of providing a nonconductive ceramic substrate having a metallic component and which can dissociate into its constituent components to provide dissociated metal bonded to the ceramic substrate upon application of laser energy. Laser energy in then applied to predetermined areas of the surface of the nonconductive ceramic substrate to provide

dissociated metallic conductors in the predetermined areas.

A further aspect of the invention is the formation of metallized through holes by application of laser energy to the nonconductive ceramic substrate to form a through hole, whereby dissociated metal ins formed on the inside of the through hole.

Still another aspect of the invention is the capability to down trim a thick film or thin film resistor which is conductively coupled between two areas of metallization. Laser energy is applied to a portion of the thick film or thin film resistor and to a portion of the metallic nonconductive ceramic substrate in a predetermined pattern to provide a continuous dissociated metallic conductor which passes through the thick film or thin film resistor and is conductively connected to one of two areas of electrically conductive metallization.

BRIEF DESCRIPTION OF THE DRAWING

The advantages and features of the disclosed invention will readily be appreciated by persons skilled in the art from the following detailed description when read in conjunction with the drawing wherein:

FIG. 1 is a schematic illustration of a conductive structure made pursuant to the process of the invention.

FIG. 2 is a schematic illustration of a conductive structure made pursuant to the process of the invention for trimming a resistor to decrease its resistance value.

FIG. 3 is a schematic illustration of metal-coated through hole made pursuant to the process of the invention.

DETAILED DESCRIPTION

In the following detailed description and in the several figures of the drawing, like elements are identified with like reference numerals.

Referring now to FIG. 1, shown therein is a plan view schematically illustrating a nonconductive ceramic substrate or insulating layer 11, for example an aluminum nitride ceramic substrate, of a hybrid circuit. The substrate 11 has a circuit device 13 mounted thereon, and further has bonding pads 15, 17, 19, 21 distributed about its periphery. The bonding pads 15, 17, 19, 21 are metallized using known thick or thin film metallization techniques, as is a conductor trace 23. Pursuant to well-known techniques, wire bonds 25 are utilized to conductively connect terminals of the the circuit device 13 to the bonding pads 15, 17, 19, 21 and the conductor trace 23.

The aluminum nitride ceramic substrate 11 of FIG. 1 further includes bonding pads 27, 29 and conductor traces 31, 33. These pads and traces 27, 29, 31, 33 comprise dissociated aluminum bonded to the aluminum nitride ceramic substrate 11. Such dissociated aluminum bonding pads and conductor traces are formed by applying laser energy to the regions of the ceramic substrate 11 where such bonding pads and conductor traces 27, 29, 31, 33 are to be formed. By way of example, the laser energy may be provided by a yttrium aluminum garnet (YAG) laser or by a carbon dioxide (CO_2) laser. The laser beam is controlled to scan the regions where the aluminum is to be dissociated from the substrate and which form the metallized interconnect pads and traces 27, 29, 31, 33. A very fine line trace is achieved, having a dimension on the order of 0.001 inch in width. This permits the formation of micro-circuits which have a greater circuit density than micro-circuits formed with conventional processing techniques.

By way of particular example, a YAG laser may be utilized to form the pads and traces 27, 29, 31, 33 with the following parameters:

Equipment: ESI Model 44 YAG Laser

Power Setting: 14.5 amps
Pulse Rate: 2000 pps
Speed: 4 mm/sec.

A particular advantage of the disclosed dissociative process is that it provides the capability of metallizing specific locations after other metallization has already been formed, for example by thick film or thin film techniques. Thus, the disclosed dissociative process can be advantageously utilized to add bonding pads and conductor traces to already fabricated circuits or prototype circuits.

A particular application of the capability of metallizing specific locations is illustrated in FIG. 2, which shows an aluminum nitride ceramic substrate 111, for example, having a thin film resistor 113 formed thereon. The thin film resistor 113 is illustrated as being coupled between two conductor pads 115, 117. A U-shaped dissociated aluminum conductor 119 extends from the conductor pad 115 and traverses the thin film resistor at a location spaced from the conductor pad 115. As a result of the dissociated aluminum conductor 119, the resistance value of the thin film resistor 113 has been reduced relative to its original resistance value, since the resistive material between the dissociated aluminum conductor 119 and the conductor pad 115 is effectively short circuited. Thus, the disclosed dissociation process can be used to trim resistors to decrease resistance values. Heretofore, the process of decreasing thick or thin film resistors formed in hybrid microcircuits was not possible with conventional resistor trimming techniques.

It is to be understood that the resistors can also be trimmed to increase their value using the laser. This is generally accomplished by using a laser to cut through a portion of the resistor in the shape of an "U", where the ends of the legs of the "U" are at an edge of the

resistor. Such cut which effectively reduces the amount of resistor material.

Referring now to FIG. 3, illustrated therein is a further use of the metal dissociating process of the present invention. A through hole 213 is formed in an aluminum nitride ceramic substrate 211, for example, by a laser. As a result of the laser energy, dissociated aluminum is formed on the inside surface of the through hole and around the openings thereof. Thus, a conductive through hole is formed without first forming a hole in the ceramic substrate 211 and then metallizing the hole as is done with known processes. Through holes formed in this manner can be utilized to interconnect circuitry on both sides of an aluminum nitride ceramic substrate or insulating layer.

The foregoing has been a disclosure of a metal dissociating process which provides several advantages and features including the capability of forming dissociated metal conductors quickly and easily without the use of known thick film or thin film metallization techniques. Further, the disclosed metal dissociating process provides for trimming resistors to decrease resistance values. Also, the dissociating process can be utilized to produce metallized through holes simply by forming a hole with a laser.

This process makes it possible to process surface layer interconnect metallization and metallize via through holes by programming a laser to directly write the conductor lines and form metallized vias. This process may be performed before or after other metallization techniques have been employed to form bonding pads or resistors or the like. A significant increase in processing speed is achieved and laborious and costly screen printing and deposition, etching and masking processes are eliminated by employing the process of the present invention. Also,

resistor trimming can be performed to decrease resistor values using the present invention.

Although the foregoing has been a description and illustration of specific embodiments of the invention, various modifications and changes thereto can be made by persons skilled in the art without departing from the scope and spirit of the invention as defined by the following claims. In particular, although aluminum nitride has been disclosed in the exemplary embodiment of the inventions, the present invention is not limited to only aluminum nitride substrates or insulating layers, but encompasses other nonconductive metallic materials which dissociate in the manner described herein.

CLAIMS

What is claimed is:

1. A process for forming electrically conductive elements on a ceramic substrate comprising the steps of:

providing a nonconductive ceramic substrate having a metallic component and which can dissociate into its constituent components to provide dissociated metal bonded to the ceramic substrate upon application of laser energy; and

applying laser energy to predetermined areas of the surface of the nonconductive ceramic substrate to provide dissociated metallic conductors in the predetermined areas.

2. The process of Claim 1 wherein the step of providing a metallic nonconductive ceramic substrate includes the step of providing an aluminum nitride ceramic substrate.

3. The process of Claim 1 wherein the step of applying laser energy includes the step of applying laser energy provided by a YAG laser.

4. The process of Claim 1 wherein the step of applying laser energy includes the step of applying laser energy provided by a carbon dioxide laser.

5. The process of Claim 1 wherein the step of applying laser energy includes the step of applying laser energy to said substrate to form a through hole in the ceramic substrate, whereby dissociated metal is formed on the inside of the through hole.

6. A process for forming electrically conductive elements on a ceramic substrate comprising the steps of:

providing a nonconductive ceramic substrate having a metallic component and which can dissociate into its constituent components to provide dissociated metal bonded to the ceramic substrate upon application of laser energy;

forming at least two areas of electrically conductive metallization on the surface of said conductive ceramic substrate;

forming a thick film or thin film resistor on the surface of said nonconductive substrate between two areas of said electrically conductive metallization; and

applying laser energy to a portion of the thick film or thin film resistor and to a portion of the metallic nonconductive ceramic substrate in a predetermined pattern to provide a continuous dissociated metallic conductor which passes through said thick film or thin film resistor and is conductively connected to one of said two areas of electrically conductive metallization.

7. The process of Claim 6 wherein the step of providing a metallic nonconductive ceramic substrate includes the step of providing an aluminum nitride ceramic substrate.

8. The process of Claim 6 the step of applying laser energy includes the step of applying laser energy provided by a YAG laser.

9. The process of Claim 6 wherein the step of applying laser energy includes the step of applying laser energy provided by a carbon dioxide laser.

10. The process of Claim 6 wherein said predetermined pattern includes a linear portion which passes through and extends beyond the thin film or thick film resistor and further includes linear portions which extend from the ends of such linear portion to one of said two areas of electrically conductive metallization.

11. A process of forming electrically conductive metallization on or through a nonconductive substrate or insulating layer of a hybrid microcircuit, said process comprising the steps of:

providing a nonconductive substrate or insulating layer having a metallic component which dissociates into its constituent components upon the application of laser energy, said metallic component rebonding to said substrate or insulating layer;

applying laser energy to predefined areas of the surface of said substrate or insulating layer to dissociate said metallic component from said substrate or insulating layer; and

removing said laser energy from said predefined areas to allow said metallic component to rebond to the surface of said substrate or insulating layer, said rebonded metallic component forming electrically conductive metallization on said surface.

12. The process of Claim 11 further comprising the steps of:

forming a thick film or thin film resistor on the surface of said substrate or insulating layer between predetermined areas of said electrically conductive metallization; and

applying and removing said laser energy to the surface of said substrate or insulating layer below

said resistor so as to short circuit a portion thereof to decrease the resistance value thereof.

13. A process of forming electrically conductive metallization on or through a nonconductive substrate or insulating layer of a hybrid microcircuit, said process comprising the steps of:

providing a nonconductive substrate or insulating layer having a metallic component which dissociates into its constituent components upon the application of laser energy, said metallic component rebonding to said substrate or insulating layer upon the removal of said laser energy; and

dissociating predetermined portions of said substrate or insulating layer to provide electrically conductive metallization comprising dissociated metallic conductors thereon or therethrough.

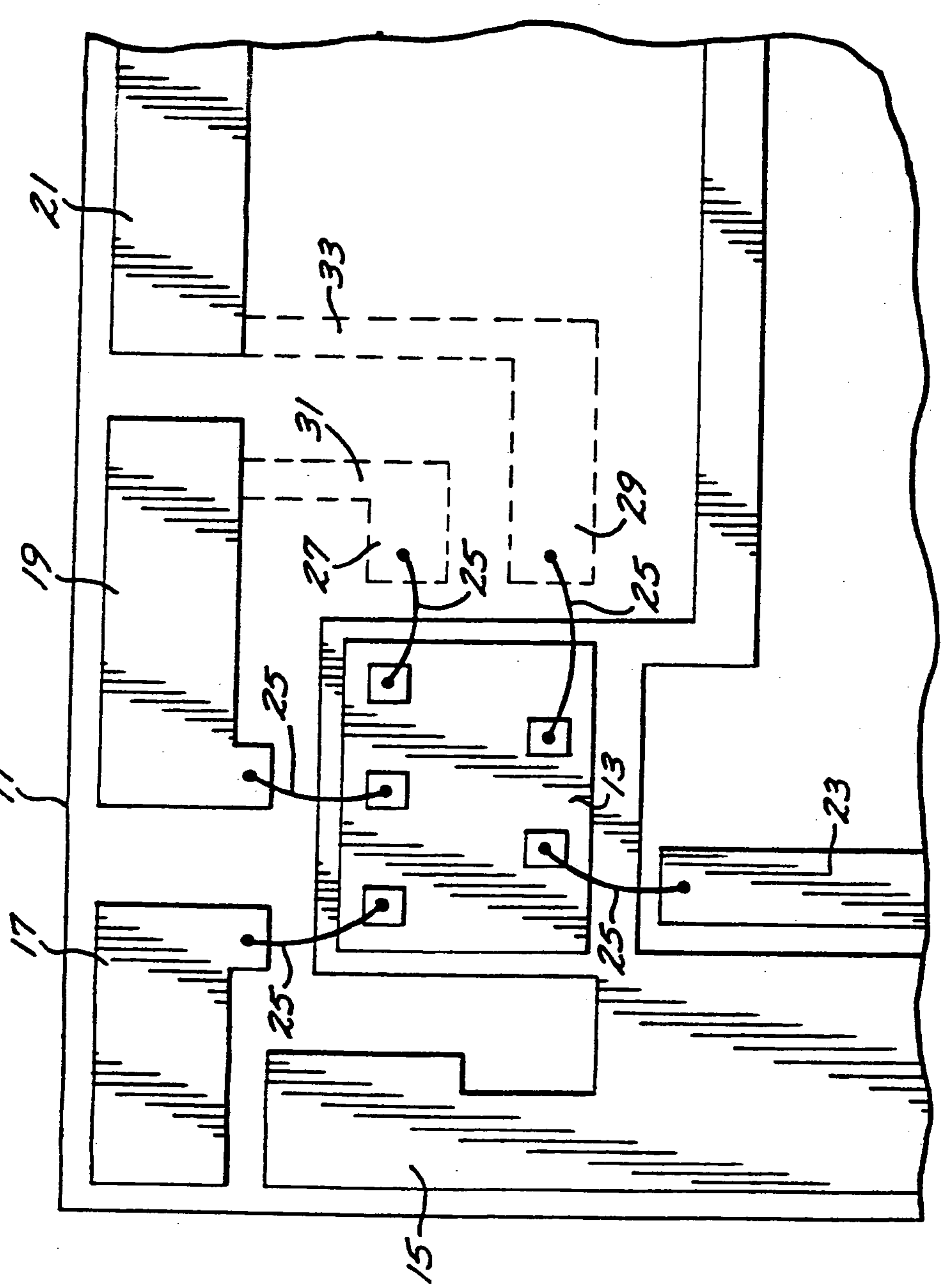

FIG. 1

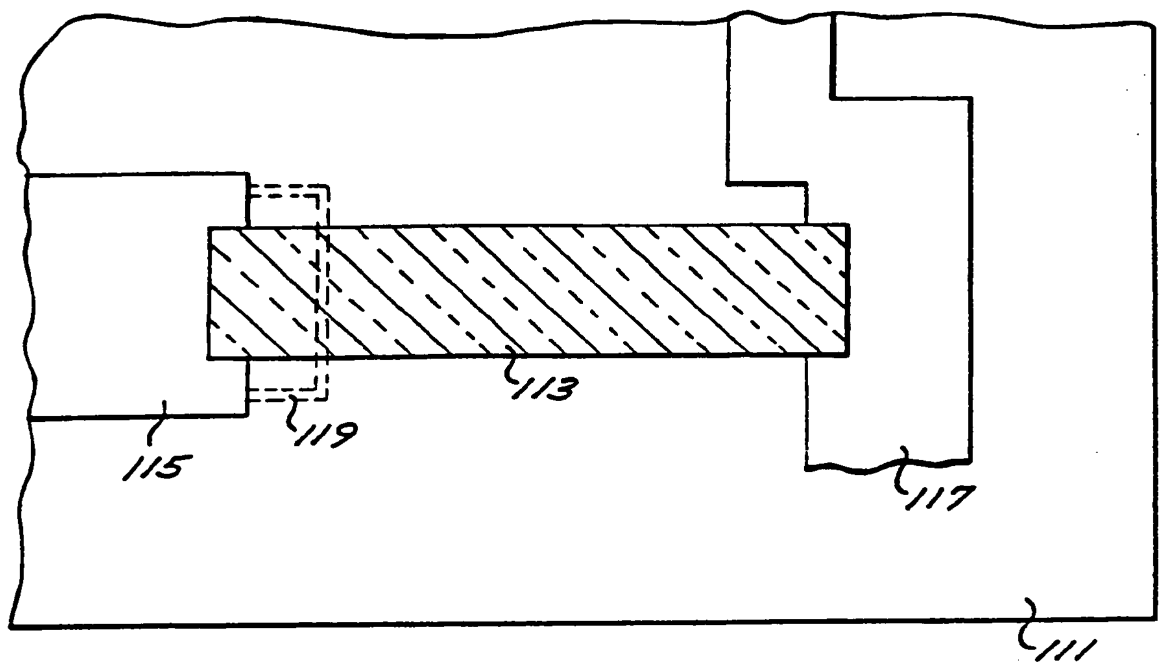

FIG. 2

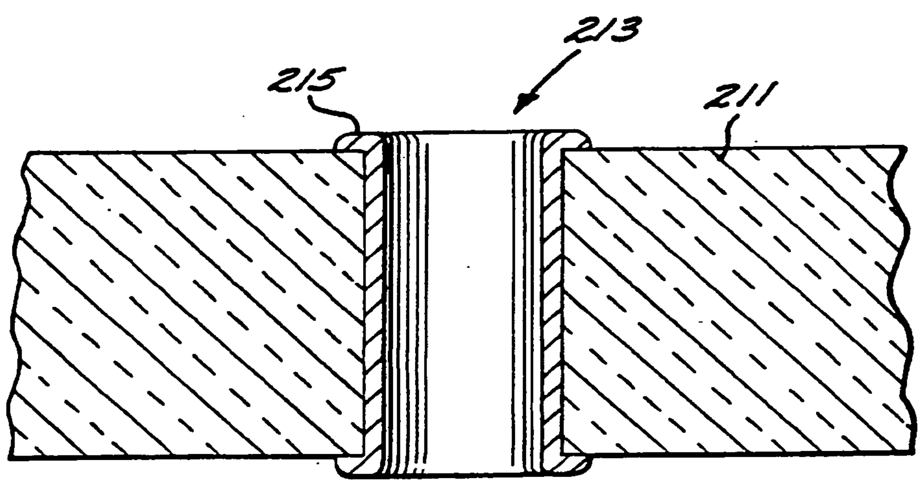

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 88/02577

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC4: H 05 K 3/10, 3/42

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC4	H 05 K, C 23 C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	EP, A1, 0227371 (KABUSHIKI KAISHA TOSHIBA) 1 July 1987, whole document --	1-13
X	US, A, 3256109 (C BERGER) 14 June 1966, see column 1, line 60 - column 2, line 8; column 3, line 2 - line 5; column 3, line 27 - line 30 --	1
Y	EP, A3, 0230128 (AMERICAN TELEPHONE AND TELEGRAPH COMPANY) 16 September 1987, see column 1, line 51 - line 55; column 2, line 44 - line 46; column 3, line 15 - line 31 --	1,3,4,6

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
21st December 1988	20 JAN 1989
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	DE, A1, 3103986 (SZEPAN REINER) 9 September 1982, see page 4 , part 1 and 2 --	1, 4, 5
A	GB, A, 1251451 (SECRETARY OF STATE FOR DEFENCE) 27 October 1971, see page 1, line 12 - line 35; page 1, line 71 - line 75 --	1
Y	IBM Technical Disclosure Bulletin, Vol 15, No 2 July 1972, page 603, see whole document --------------	1, 4

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/US 88/02577

SA 24607

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US-A- 3256109	14/06/66	NONE	
EP-A2- 0230128	29/07/87	JP-A- 62159493 US-A- 4691091	15/07/87 01/09/87
DE-A1- 3103986	09/09/82	NONE	
GB-A- 1251451	27/10/71	NONE	

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